Furbearer Harvest Study, Gates of the Arctic National Park and Preserve, Alaska

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Abstract: From 1988-1993, red fox (Vulpes vulpes), lynx (Felis lynx), and wolverine (Gulo gulo) carcasses and marten (Martes americana) heads were purchased from trappers operating in and near Gates of the Arctic National Park and Preserve, Alaska. Carcasses were necropsied to obtain sex, age, body condition, and reproductive information. More male than female red foxes were taken from the northern part of the park during the study ($P < 0.05$), but a 1:1 sex ratio was obtained from the eastern part of the park. In the northern area of the park, 80% of the adult female red foxes and 50% of the juvenile females (< 2 years old) had placental scars, and mean litter size (based on placental scars) was 5.9. In the eastern part of the park, all adult female red foxes and 38% of the juveniles had placental scars, and mean litter size was 5.3. More female than male lynx were harvested during the study ($P < 0.05$), and juveniles comprised 32% of the harvest. Placental scars were found in 70% of the adult female lynx and 56% of the juvenile females, and mean litter size was 4.4. The male:female sex ratio for harvested wolverines was 2:1 for all years combined, and juveniles accounted for 74% of the harvest. No juvenile wolverines were reproductively active, but 4 of 9 adult females had placental scars or fetuses. More male marten were harvested during the study than females ($P < 0.05$). The number of juvenile marten harvested declined during the study, and the juvenile:adult female ratio dropped from 7.3:1 in 1988-89 to 1.4:1 in 1992-93. Monitoring strategies for each species include continued harvest monitoring, prey density studies, and identification of critical habitat.

INTRODUCTION

The National Park Service (NPS) is directed by Title II, sec. 201 of the 1980 Alaska National Interest Lands Conservation Act (ANILCA) to "...protect habitat for and the populations of fish and wildlife..." in Gates of the Arctic National Park and Preserve (GAAR). ANILCA also requires NPS to provide for subsistence use of park resources by local residents (Title VIII, sec. 802). Furbearers (beaver (*Castor canadensis*), red fox, lynx, marten, wolf (*Canis lupus*), and wolverine) constitute an important resource for trappers living in the 10 resident zone communities of Alatna, Allakaket, Ambler, Anaktuvuk Pass, Bettles/Evansville, Hughes, Kobuk, Nuiqsut, Shungnak, and Wiseman; subsistence users in these villages are permitted to trap in park lands. To protect and maintain healthy furbearer populations in the park and preserve and continue to provide for subsistence use of these resources, harvest information and basic furbearer population data is necessary.

Little information concerning furbearer populations or harvest in the vicinity of the park and preserve is available. Wolf population ecology and harvest, particularly in the Anaktuvuk Pass area, was studied by the Alaska Department of Fish and Game (ADF&G) and NPS Alaska Regional Office staff from 1986-92 (Adams and Stephenson 1986, 1988, Adams et al. 1989). Estimates of relative abundance for furbearers have been obtained through aerial furbearer track counts in GAAR (Golden 1988) and in Yukon Flats National Wildlife Refuge, east of GAAR (Golden 1987). Wolverine density has been estimated from aerial track surveys northeast of the park in Arctic National Wildlife Refuge (Mauer 1985) and by extrapolating home range sizes from radio-collared wolverines northwest of the park in the National Petroleum Reserve (Magoun 1985). The relative abundance of marten and lynx in post-fire seral stages has been obtained on the Nowitna National Wildlife Refuge by counting track intercepts along snowmachine transects (Johnson and Paragi 1993).

Sealing records, furbuyer records, and fur export permit data have been used by ADF&G to monitor furbearer populations throughout the state (Morgan 1990, Abbott 1993). In areas where trapper compliance with sealing requirements is high, this data may be adequate to monitor furbearer harvest. However, in the northern part of the state, ADF&G offices and sealing agents are scarce and animals taken for personal or handicraft use are seldom sealed. Generally, furbearer pelts are sealed by rural residents only if they are sold to furbuyers or shipped out for commercial tanning (Carroll 1993). Magoun (1985) believed that only 10% or less of the actual harvest in Game Management Unit 26 was reported in some years. Under these circumstances, sealing records may severely underestimate the actual harvest.

To examine furbearer population trends and health, park resource management staff began purchasing and necropsying furbearer carcasses from trappers working in and near the park and preserve (Golden 1988, Swanson 1992a, 1992b). The goal of this project was to collect basic information on furbearer populations and harvest in the park and preserve areas. To meet this goal the following objectives were developed: (1) determine the sex and age structure of the furbearer harvest in and near the park and preserve and (2) examine the health and reproductive characteristics of furbearers harvested in and near the park and preserve.

This study was funded through the resource management division of GAAR and the Natural Resources Division of the NPS Alaska Regional Office. The following individuals assisted with fieldwork and data collection: Layne Adams, Bob Ahgook, Michael Britten, Annette Burroughs, Donna DeVoe, Ken Faber, Ed Forner, Susan Holly, Bob Mauer, Patty Rost, Dave Schmitz, Bob Stephenson, and Ron Sutton. Many thanks to ADF&G for providing copies of the state furbearer sealing records and allowing us to use their laboratory in Fairbanks for necropsy work. Randy Zarnke (ADF&G) identified parasites and provided information on diseases and other physical anomalies. Editorial reviews on the draft of this report were given by Robin Eagan (ADF&G), Buddy Johnson (U.S. Fish and Wildlife Service [USFWS]), Tom Paragi (USFWS), Audrey Magoun (ADF&G), and Patty Rost (NPS). This study could not have been completed without the assistance of trappers working out of Anaktuvuk Pass, Bettles, Kobuk, Nolan, and Wiseman.

STUDY AREA

Gates of the Arctic National Park and Preserve is located above the Arctic Circle (66° 33'N latitude) in the central Brooks Range, Alaska (Fig. 1). The 33,182 km^2 park and preserve unit is approximately 250 miles north of Fairbanks, AK. Two climate zones occur in the park and preserve: the subarctic zone at lower elevations south of the Brooks Range divide and the arctic zone to the north and at high elevations. Precipitation is low within the park and preserve and yearly averages fall between 30-46 cm in the west and 13-25 cm in the north (National Park Service 1986). Snow fall averages between 152-203 cm in the south and 89-127 cm in the north. Yearly temperatures in the south fluctuate from an average July maximum of 21° C (70° F) to an average January minimum of -34° C (-30° F). Temperatures in the north fluctuate from an average July maximum of 18° C (65° F) to an average February minimum of -23° C (-10° F).

Boreal forest, tundra, and shrub thicket are the major vegetation communities in the park and preserve (National Park Service 1986). Boreal forest covers the southern flanks and valleys of the Brooks Range and is composed of black spruce (*Picea mariana*), white spruce (*P. glauca*), paper

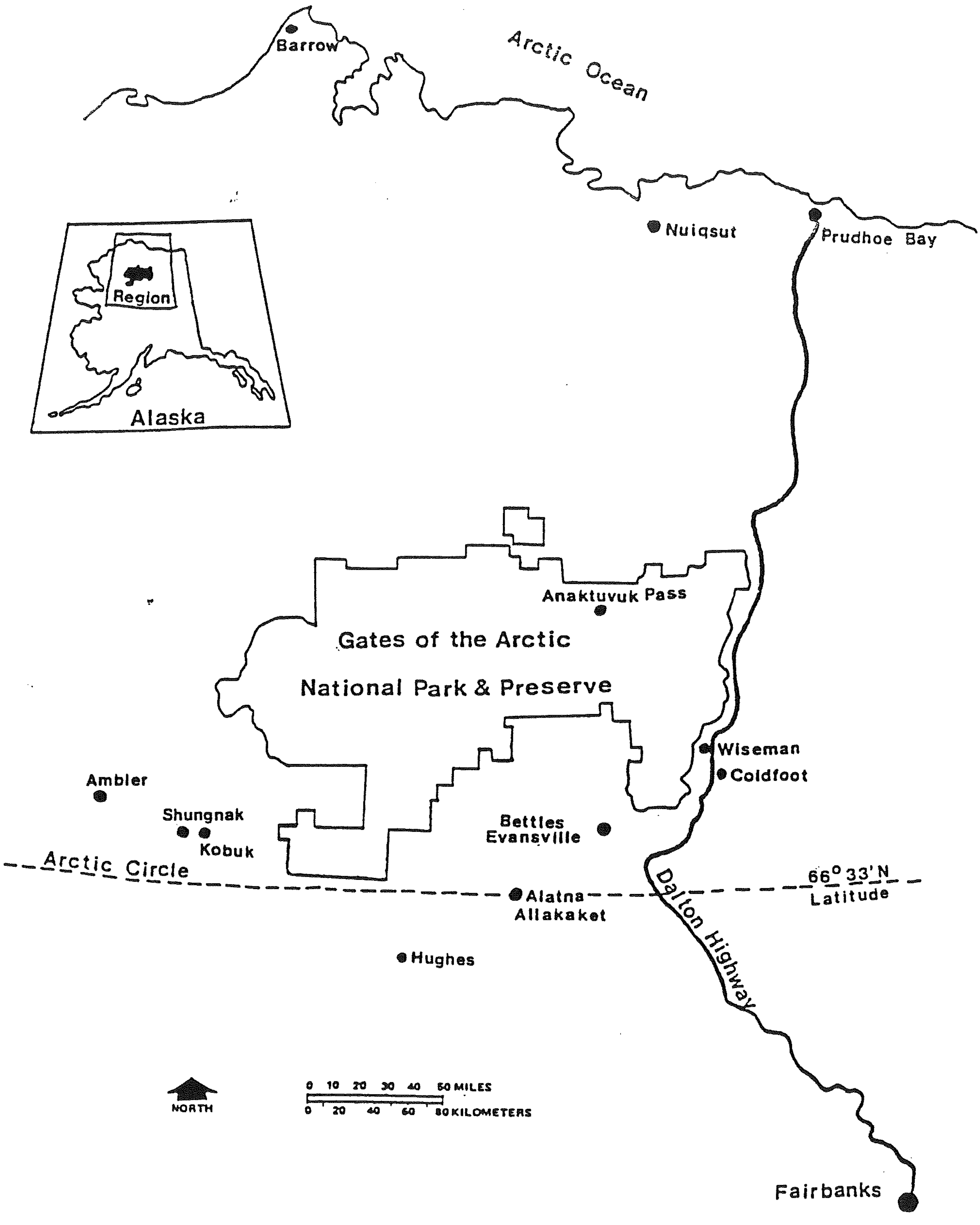

Fig. 1. Location of Gates of the Arctic National Park and Preserve, Brooks Range, Alaska.

birch (Betula papyrifera), aspen (Populus tremuloides), and balsam poplar (Populus balsamifera). Tall, dense willow (Salix spp.)/alder (Alnus spp.) thickets up to 3.5 m in height occur along stream channels and gravel bars. At treeline, boreal forest is replaced by low shrub thickets of birch (Betula spp.), willow, and alder. Alpine tundra has dwarf willow, Dryas spp., Saxifraga spp., and lichen components and is found at high elevations and on dry ridges. These vegetation communities are found in the eastern and southern carcass collection areas (Figs. 2 and 3).

Moist tundra is the predominant vegetation community on the north side of the Brooks Range. It is composed primarily of cotton sedge (Eriophorum spp.) and forms on moderate to poorly drained soils. Low willow thickets line stream channels and low-lying areas. This vegetation community makes up the northern carcass collection area (Fig. 2).

METHODS

Field Methods

Furbearer carcasses were purchased from trappers operating in and near the park and preserve during 5 trapping seasons (winters 1988-89 to 1992-93). Carcasses were necropsied and the following data was collected: (1) sex, (2) contour body, skull, and upper canine (tip to gumline) lengths, (3) heart girth, (4) external fat depths, (5) visceral fat estimation, (6) gastro-intestinal contents, (7) parasites, and (8) infirmities. Placental scars were counted from uterine tracts to assess previous reproductive effort; no staining or clearing techniques were used to enhance placental scar visibility. In 1990, ovaries of lynx, wolverine and red fox were preserved in formaldehyde and corpora lutea were counted (Swanson 1992a). Canine teeth were collected from all species except marten for age determination (Matson and Matson 1993). Juvenile red foxes, lynx, and wolverines were defined as animals <2 years old, based on tooth cementum annuli. Lynx tongues were collected for ADF&G biologists studying the incidence of Trichinella spiralis in lynx.

Skulls of each species were cleaned for exhibit specimens and collections were sent to schools in Bettles and Anaktuvuk Pass. Skulls and samples of liver, kidney, heart, and muscle tissue from lynx, wolverine, red fox, arctic fox, and a coyote taken near Anaktuvuk Pass were collected for the University of Alaska Museum frozen tissue collection. In 1993, muscle tissue samples from lynx, red fox, and wolverine were sent to the U.S. Fish and Wildlife Service (USFWS) Forensics Laboratory in Ashland, Oregon to serve as DNA profile reference material.

Skull length and temporal muscle closure were used to determine marten juveniles (<1 year old) from adults and males from females (Magoun et al.

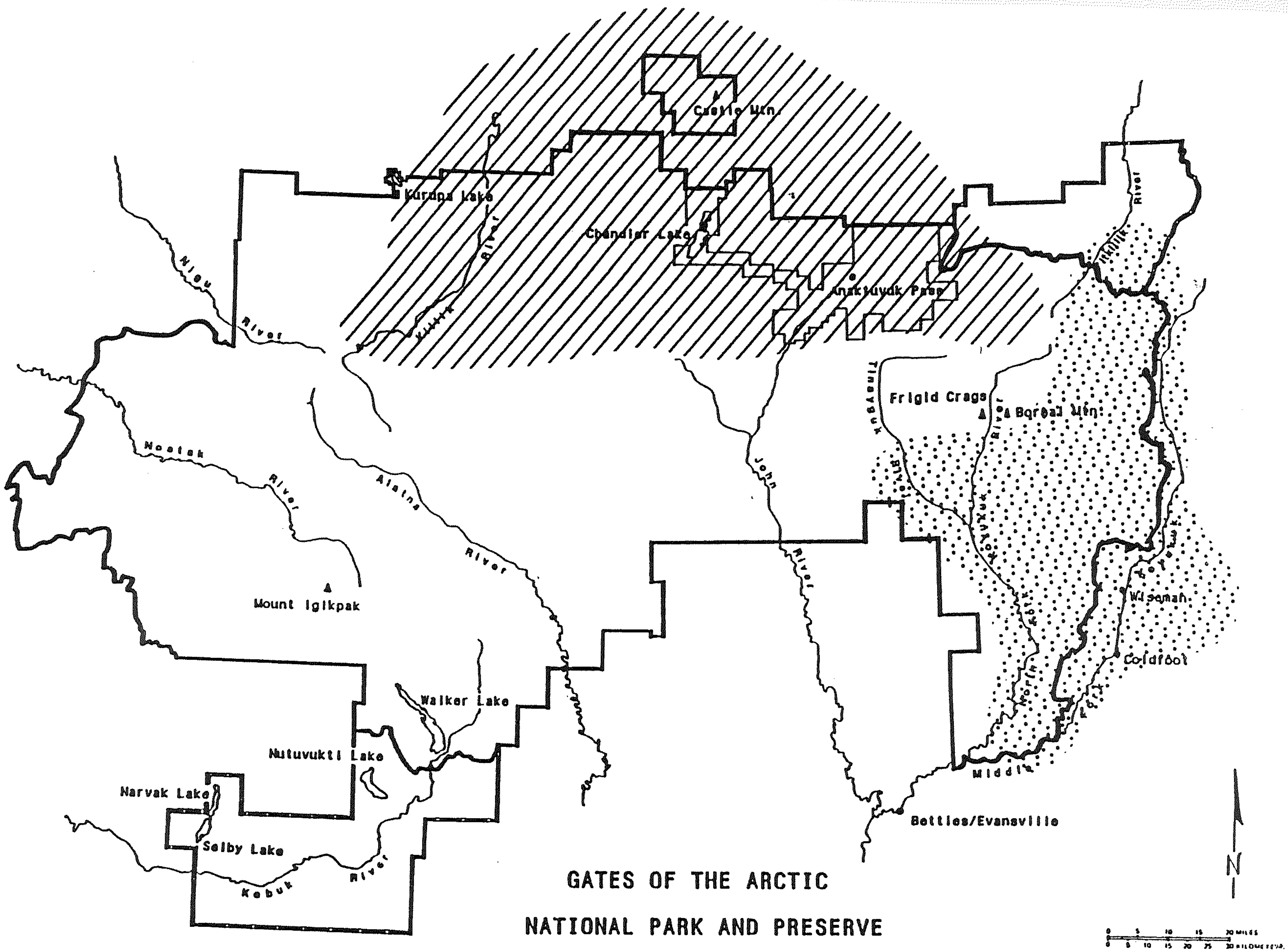

Fig. 2. Location of the northern and eastern carcass collection areas, Gates of the Arctic National Park and Preserve, Brooks Range, Alaska, 1988-1993.

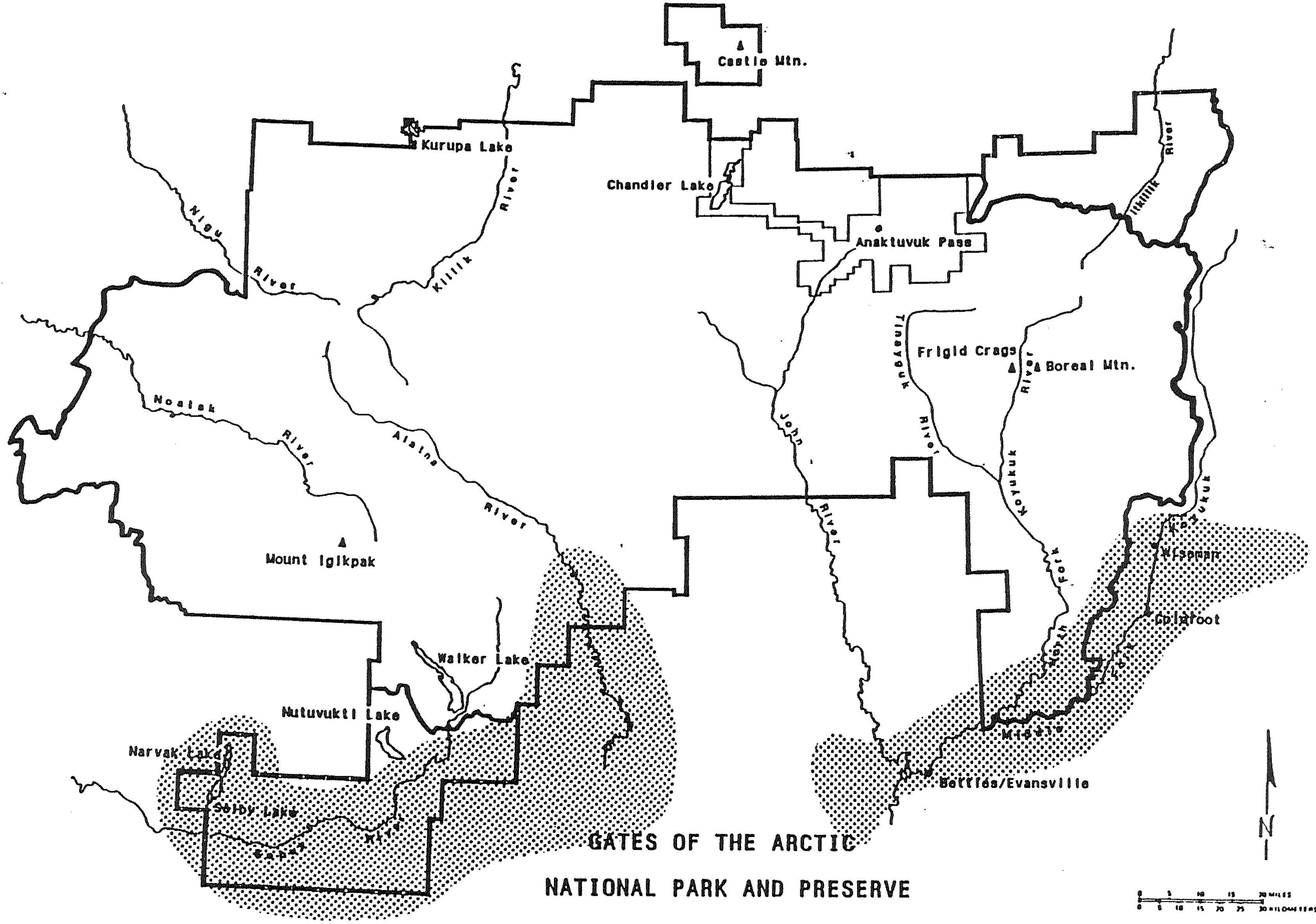

Fig. 3. Location of the southern marten collection area, Gates of the Arctic National Park and Preserve, Brooks Range, Alaska, 1988-1993.

1991). In 1990, the canine and first and second premolars of 11 marten were aged by tooth cementum analysis to compare the accuracy of the method using different teeth and to investigate the possibility of pulling a first premolar from live-trapped marten to determine age (Swanson 1992a).

Statistical Methods

Binomial probability distribution was used to test for male:female and juvenile:adult ratios differing from 50:50 for each species. Differences in parasite incidence in red fox between the northern and eastern study areas were compared using the Chi-squared test (X^2; Bailey 1981). Mann-Whitney U test was used to determine variation in visceral fat levels between red fox trapped in the northern and eastern areas. Fluctuations in carcass visceral fat content between trapping seasons for lynx and wolverine were examined using Kruskal-Wallis One-way Analysis of Variance. Binomial Probability, Mann-Whitney U, and Kruskal-Wallis statistics were computed using STATISTIX version 4.0 (Analytical Software, Tallahassee, FL).

RESULTS

Carcasses of 231 red foxes, 129 lynx, 54 wolverines, 6 arctic foxes, and 1 coyote were purchased from trappers working in the northern and eastern portions of the park. Although some carcasses were purchased from trappers working south of the park (21 red fox and 8 lynx), data presented in this report is only from those animals trapped in the northern and eastern portions of the park (Fig. 2). Sex and age data was collected from 1000 marten, most of which were trapped south and southeast of the park (Fig. 3). The number of trappers participating in the project each year by species is given in Appendix I.

Red Fox

Since moist tundra predominates in the northern part of the park and the east is largely boreal forest, data from red fox carcasses purchased from these 2 different habitat areas are presented separately.

Sex and Age.--Though overall, more males than females were trapped in the northern area of the park during the study, only the 1991-92 trapping season resulted in a male:female ratio different from 50:50 (Binomial Probability, $\underline{P} < 0.05$; Table 1). Juveniles (including pups) accounted for >75% of the harvest in all trapping seasons and 85% of the overall aged harvest ($\underline{n} = 119$); pups alone accounted for 63% (Fig. 4; Table 1). The number of juveniles taken per adult female was high (Table 1).

In the eastern part of the park, the number of trapped male red foxes did not

Table 1. Sex and age composition of red fox trapped in the northern area of Gates of the Arctic National Park and Preserve, Brooks Range, Alaska, 1988-1992. Sex composition is given as the percentage of males (M):females (F) for a sample size of n. Age composition data consists of percent juveniles (J), percent pups, and the percentage of juveniles:adult females (AF). (Juveniles are animals <2 years old as determined by tooth cementum aging.)

Trapping Season	M:F	(n)	% J	(n)	% Pups	(n)	J:AF	(n)
1988-89	1.1:1 (53:47)	79	80	76	62	76	9:1 (90:10)	67
1989-90	2:1 (67:33)	15	100	10	40	10	- (100:0)	10
1990-91	1.8:1 (64:36)	22	77	22	64	22	8.1:1 (89:11)	19
1991-92	3.1:1[a] (76:24)	21	100	11	91	11	- (100:0)	11
Total	1.5:1[a] (60:40)	137	82	119	63	119	11.5:1 (92:08)	107

[a] $P < 0.05$; Binomial Probability Test to determine divergence from a 50:50 distribution.

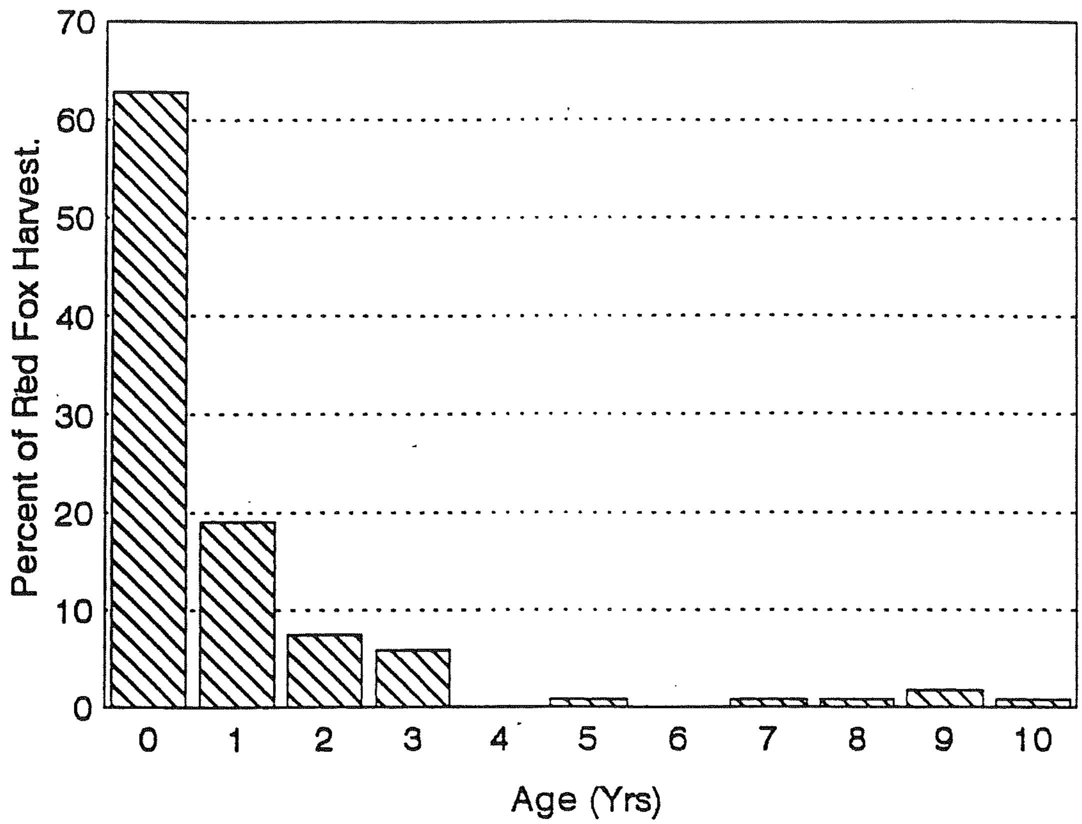

Fig. 4. Age distribution of 119 red foxes trapped in the northern area of Gates of the Arctic National Park and Preserve, Brooks Range, Alaska, 1988-1992.

differ from the number of females within any year of the study (Binomial Probability, $P > 0.05$). Juveniles (including pups) accounted for >50% in all trapping seasons and 73% of the 5-year pooled harvest ($n = 66$; Table 2). The percentage of pups in the harvest ranged from 26% to 63% and 41% of the overall harvest (Fig. 5; Table 2). Juvenile:adult female ratios were biased towards juveniles (Table 2).

Reproduction.--Eight of the 10 adult females (80%) examined from the northern part of the park had placental scars. Of the 12 yearling females, 6 (50%) had placental scars. Mean litter size (based on placental scars) from 14 harvested red fox in the northern part of the park was 5.9.

Placental scars were present in all of the 10 adult females examined from the eastern area of the park and preserve. Five of the 13 yearling females examined (38%) had placental scars. Based on placental scars, the mean litter size for 15 red foxes in the eastern area of the park was 5.3.

Body Condition--Visceral fat levels were higher in red fox harvested in the north than in those harvested in the east ($P = 0.002$, Mann-Whitney U test; Table 3). Incidence of parasites did not differ between the northern and eastern areas ($P = 0.20$, $X^2 = 1.62$, d.f. = 1). Free-roaming nematodes were found in 29% of the red fox carcasses examined for parasites from the north ($n = 137$) and 21% of the carcasses from the east ($n = 71$). Encysted nematodes also were found in 21% of the red foxes harvested in the east ($n = 71$).

Gastro-intestinal Contents.--Stomach contents for red foxes were the most diverse of the 3 species examined. Separation of natural foods from trap bait and garbage was not possible. Gastro-intestinal contents identified from red foxes taken in the northern and eastern areas of the park included the following: microtines, moose (*Alces alces*) hair and meat, unidentified ungulate hair and meat, snowshoe hare (*Lepus americanus*), caribou (*Rangifer tarandus*), grouse/ptarmigan, blueberries, lemmings, unidentified feathers, and fish. One fox had eaten lemmings that had been eating blueberries. Human refuse from dumps, such as corn, plum pits, and disposable diaper material, was found in the stomachs of foxes trapped near villages. Parts of fox feet (toes, claws, bones, and fur) were located in several gastro-intestinal tracts. Stomachs were empty in 66% of the red foxes examined during the study ($n = 210$).

Lynx

Only 2 lynx were taken by trappers operating from the northern portion of the park during the study. The following results are from 115 lynx harvested in the eastern part of the park .

Table 2. Sex and age composition of red fox trapped in and near the eastern portion of Gates of the Arctic National Park and Preserve, Brooks Range, Alaska, 1988-1993. Sex composition is given as the percentage of males (M):females (F) for a sample size of n. Age composition data consists of percent juveniles (J), percent pups, and the percentage of juveniles:adult females (AF). (Juveniles are animals <2 years old as determined by tooth cementum aging.)

Trapping Season	M:F	(n)	% J	(n)	% Pups	(n)	J:AF	(n)
1988-89	1:1 (50:50)	8	88	8	63	8	7.3:1 (88:12)	8
1989-90	0.6:1 (38:62)	13	100	8	38	8	- (100:0)	8
1990-91	4:1 (80:20)	10	80	10	40	10	- (100:0)	8
1991-92	0.9:1 (47:53)	17	76	17	53	17	3.2:1 (76:24)	17
1992-93	0.8:1 (43:57)	23	52	23	26	23	3:1 (75:25)	16
Total	1:1 (49:51)	71	73	66	41	66	5:1 (84:16)	57

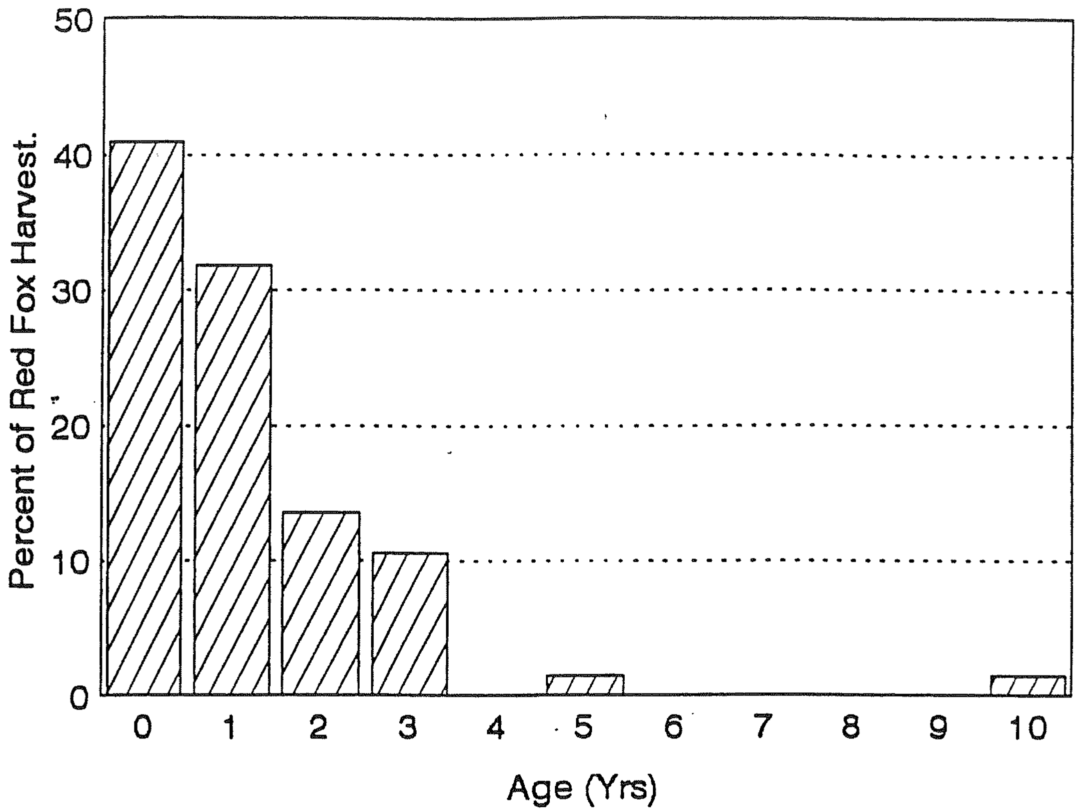

Fig. 5. Age distribution of 66 red foxes trapped in the eastern area of Gates of the Arctic National Park and Preserve, Brooks Range, Alaska, 1988-1993.

Table 3. Mode and median visceral fat rankings for red fox trapped in northern and eastern areas of Gates of the Arctic National Park and Preserve, Brooks Range, Alaska, 1988-1993. Visceral fat levels were ranked on the following scale: 0 = none, 1 = scarce, 2 = moderate, and 3 = abundant.

Trapping Season	Northern n	Northern Median	Northern Mode	Eastern n	Eastern Median	Eastern Mode	P[a]
1988-89	81	1	1	8	0	0	0.013
1989-90	15	2	3	13	0	0	0.077
1990-91	22	2	3	10	1	1	0.095
1991-92	21	1	0	16	1	1	0.004

[a]Mann-Whitney test between areas.

Sex and Age.--The number of male lynx did not differ from the number of female lynx during any of the trapping seasons, but sample sizes for 3 of the 5 seasons were small (Table 4). However, more females than males were found in the overall sex ratio (Binomial Probability, $P < 0.05$). Few juveniles or kits were harvested during the study (Table 4). More adult lynx were taken than juveniles during the 1992-93 trapping season and overall for the study (Binomial Probability, $P < 0.05$). Lynx juvenile to adult female ratios were low during the study (Table 4). Of the 109 lynx examined during the study, 32% were juveniles (including kittens) and kittens alone accounted for 12% (Fig. 6).

Reproduction.--The mean litter size (based on placental scars) for 40 female lynx was 4.4. Placental scars were observed in 70% of the adult female lynx ($n = 46$), and in 56% of the juvenile female lynx ($n = 9$).

Body Condition.--Mode and median visceral fat levels in necropsied lynx were moderate to abundant and did not vary between years ($P = 0.08$, Kruskal-Wallis test; Table 5). Parasites were found in 50% of the lynx ($n = 115$) and included both free-roaming and cystic nematodes (*Cyclospirura* spp.). Nematode cysts were found in 32% of the lynx examined. Unidentified flatworms (tapeworms) were found in the small intestines of 2 lynx from the 1991-92 trapping season.

Cysts of *Trichinella spiralis* were detected in 23% of 43 lynx tongues examined for the parasite in 1991-92 and 24% of 49 lynx in 1992-93 (R. L. Zarnke, AK Dep. Fish and Game, pers. commun.). In 1990-91, 5 of 10 lynx tested positive for *Trichinella spiralis*. The sample in 1990-91 included 6 lynx older than 8 years, 4 of which tested positive for *Trichinella spiralis*; the likelihood that an animal will feed on an infected carcass and contract the infection itself increases with age. A statewide incidence of 20-30% in lynx is projected (R.L. Zarnke, AK Dep. of Fish and Game, pers. commun.).

Gastro-intestinal Contents.--In addition to trap debris and bait, the following stomach contents were identified in lynx: Dall sheep (*Ovis dalli*), snowshoe hare, unidentified ungulate hair and meat, grouse/ptarmigan, caribou, unidentified feathers, and meat from unknown sources. Lynx claws, fur, and bits of bone were also identified from stomach contents. One adult lynx had the ear and fur of a lynx kitten in its stomach. Over 80% of the lynx had empty stomachs or stomachs containing only trap debris/vegetation. Empty stomachs suggest long periods of time spent in traps prior to removal.

Table 4. Sex and age composition of lynx trapped in and near the eastern portion of Gates of the Arctic National Park and Preserve, Brooks Range, Alaska, 1988-1993. Sex composition is given as the percentage of males (M):females (F) for a sample size of _n_. Age composition data consists of percent juveniles (J), percent kits, and the percentage of juveniles:adult females (AF). (Juveniles are animals <2 years old as determined by tooth cementum aging.)

Trapping Season	M:F	(_n_)	% J	(_n_)	% Kits	(_n_)	J:AF	(_n_)
1988-89	1:1 (50:50)	2	-	2	-	2	- (0:100)	1
1989-90	1.5:1 (60:40)	5	60	5	60	5	1.5:1 (60:40)	5
1990-91	0.8:1 (44:56)	9	22	9	11	9	0.5:1 (33:67)	6
1991-92	0.7:1 (41:59)	41	46	41	15	41	1.3:1 (56:44)	34
1992-93	0.7:1 (40:60)	58	21	52	6	52	0.5:1 (31:69)	35
Total	0.7:1[a] (42:58)	115	32	109	12	109	0.8:1 (43:57)	81

[a] $P < 0.05$; Binomial Probability Test to determine divergence from a 50:50 distribution.

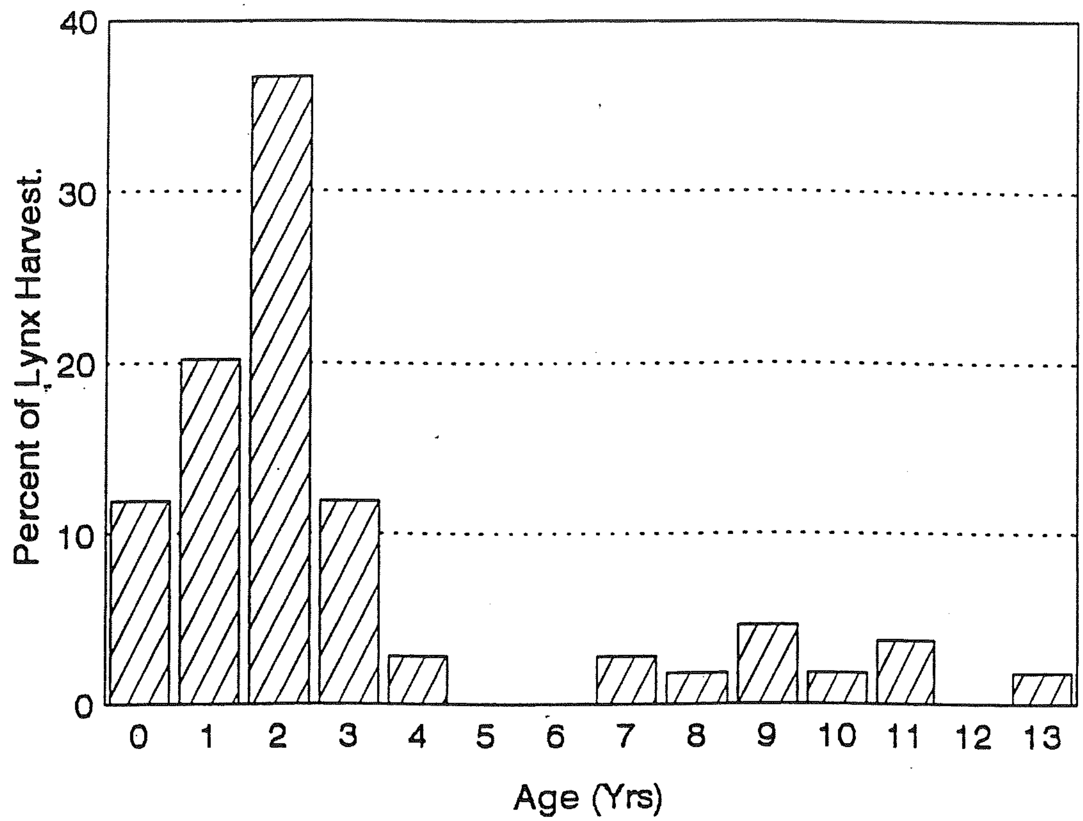

Fig. 6. Age distribution of 109 lynx trapped in the eastern area of Gates of the Arctic National Park and Preserve, Brooks Range, Alaska, 1988-1993.

Table 5. Mode and median visceral fat rankings for lynx and wolverine trapped in and near Gates of the Arctic National Park and Preserve, Brooks Range, Alaska, 1988-1993. Visceral fat levels were ranked on the following scale: 0 = none, 1 = scarce, 2 = moderate, and 3 = abundant.

Trapping Season	Mode Rank	Median Rank	Sample Size (*n*)	*P*[a]
Lynx (Eastern area)				
1988-89	-	2.5	2	
1989-90	2	2	5	
1990-91	3	3	9	
1991-92	3	3	41	
1992-93	3	3	58	
				0.079
Wolverine (Eastern and Northern areas)				
1988-89	-	1.5	12	
1989-90	1	1	10	
1990-91	3	2.5	9	
1991-92	3	3	19	
1992-93	2	2	4	
				0.049

[a]Kruskall-Wallis one-way analysis of variance test between years.

Wolverine

Because wolverines have extensive home ranges, wolverine data from both the northern and eastern trapping areas of the park are combined for analysis in this section.

Sex and Age.--Overall, more male than female wolverines were trapped during the 5-year study (Binomial Probability, $P < 0.05$; Table 6). More males than females were trapped during the 1991-92 trapping season ($P < 0.05$), but sex ratios from other trapping seasons did not differ significantly from 1:1 (Table 6). Juveniles made up a high percentage of the harvest, though only during the 1991-92 trapping season were significantly more juveniles than adults taken (Binomial Probability, $P < 0.05$). Juvenile wolverines (including kits) accounted for 74% of the 47 wolverines harvested during the study, while kits alone accounted for 38% (Fig. 7).

Reproduction.--Four of 9 adult (2 years old and older) female wolverines had placental scars or fetuses, but none of the juvenile wolverines had either placental scars or fetuses. Three of the 5 adult female wolverines without placental scars or fetuses were captured in November or December when only corpora lutea or blastocysts in the uterus (neither were recorded) would indicate reproductive activity.

An 11-year-old wolverine captured in early February 1993 had 4 developing fetuses (2 males, 2 females) and 1 partially reabsorbed fetus. Crown lengths of these fetuses ranged from 43.7 - 47.2 mm. A 2-year-old female captured in late February/early March 1992 had 3 fully developed fetuses (2 female, 1 male) ranging in crown length from 173 - 195 mm. Two 2-year-old females were identified with placental scars; one, captured in November 1989, had a discolored, muscular uterus with 3 scars and the other, captured in March 1991, had 2 placental scars. Based on placental scars and presence of fetuses, the mean litter size for 4 wolverines was 3.0.

Body Condition.--Wolverine visceral fat levels differed between years ($P = 0.05$, Kruskal-Wallis Test; Table 5). Median wolverine visceral fat levels ranged from scarce in the 1989-90 trapping season to abundant in 1991-92. Parasites were located in 24% of the wolverines examined and 1 wolverine had a nematode cyst. Nematodes collected from 1 wolverine were identified as *Soboliphyme baturini* and *Baylisascaris devosi* (E. Holberg, Atlantic Vet. Coll., pers. commun.).

Gastro-intestinal Contents.--Over 70% of the 54 wolverine stomachs were empty or contained only trap debris such as rocks, spruce needles, and vegetation. Snowshoe hare, caribou meat and hair, unidentified feathers,

Table 6. Sex and age composition of wolverine trapped in and near Gates of the Arctic National Park and Preserve, Brooks Range, Alaska, 1988-1993. Sex composition is given as the percentage of males (M):females (F) for a sample size of _n_. Age composition data consists of percent juveniles (J), percent kits, and the percentage of juveniles:adult females (AF). (Juveniles are animals <2 years old as determined by tooth cementum aging.)

Trapping Season	M:F	(_n_)	% J	(_n_)	% Kits	(_n_)	J:AF	(_n_)
1988-89	3:1 (75:25)	12	64	11	27	11	3.6:1 (78:22)	9
1989-90	0.7:1 (40:60)	10	62	8	25	8	2.5:1 (71:29)	7
1990-91	2:1 (67:33)	9	75	8	13	8	3:1 (75:25)	8
1991-92	5.3:1[a] (84:16)	19	87	16	63	16	6.7:1 (87:13)	16
1992-93	1:1 (50:50)	4	75	4	50	4	3:1 (75:25)	4
Total	2:1[a] (67:33)	54	74	47	38	47	4:1 (80:20)	44

[a] $P < 0.05$; Binomial Probability Test to determine divergence from a 50:50 distribution.

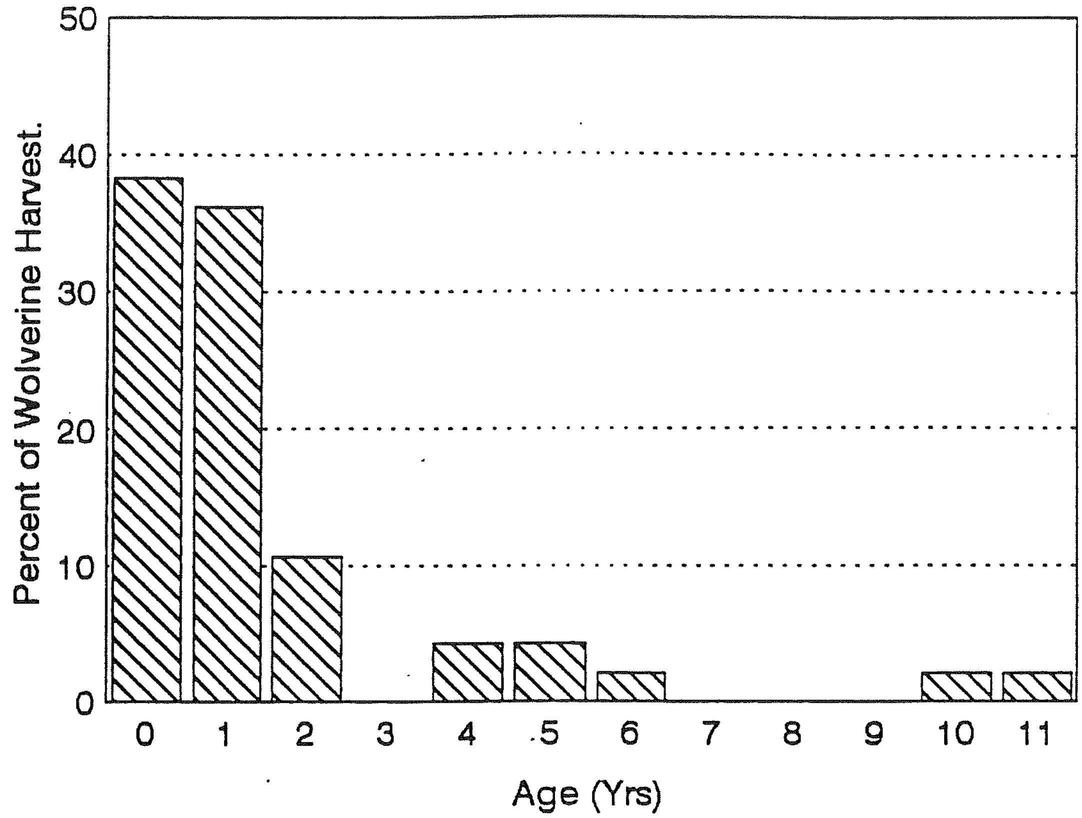

Fig. 7. Age distribution of 47 wolverine trapped in and near Gates of the Arctic National Park and Preserve, Brooks Range, Alaska, 1988-1993.

and unidentified ungulate meat were found in wolverine gastro-intestinal tracts. Fragments of wolverine bone, hair, and claws also were identified in stomach contents.

Marten

Marten heads were collected from trappers working along the southern foothills of the Brooks Range from the Kobuk Preserve Unit of the park to the Bob Johnson Lake area, 18 miles east of Wiseman (Fig. 3). Because this area represents the northernmost extension of marten range in the state, all marten data was combined and analyzed as one sample.

Sex and Age.--More male marten were taken than females in all 5 years of the study (Binomial Probability, $\underline{P} < 0.05$; Table 7). The proportion of juvenile marten in the harvest declined significantly from 1988 to 1993 (Table 7; Fig. 8). Though more juveniles than adult females were taken during all trapping seasons, the juvenile:adult female ratio declined from 7.3:1 in 1988-89 to 1.4:1 in 1992-93 (Table 7). During the 1992-93 trapping season, adult males accounted for >50% of the harvest and more adult males were harvested than juveniles (Fig. 8).

DISCUSSION

The difficulty and expense of studying furbearers has resulted in a general lack of management information. Consequently, management decisions often are based on harvest statistics, subjective information, best professional guesses, and results of limited research projects in specific areas (Hash 1987). Using harvest data to assess population trends within natural populations requires caution as harvest data probably reflects harvest effort and methods more than population level changes (Erickson 1982). Harvest levels are influenced by trapper effort, economic conditions, fur prices, weather, species abundance, and regulation changes, all of which make annual comparisons of harvest records difficult. Additionally, animals taken by trappers may not constitute a representative sample of the population, since males are frequently captured more often than females and young animals are more vulnerable to trapping than adults (Gilbert 1987). However, Erickson (1982) believed that harvest data summarized by locality could be used to determine geographical differences in abundance and identify temporal shifts in abundance and distribution. Voigt (1987) stated that monitoring harvest was currently still the best method to detect change in red fox populations.

Reproductive information from furbearer carcasses, such as counts of corpora lutea, blastocysts in delayed implanters, placental scars, or fetuses, is often used to interpret furbearer population density and reproductive

Table 7. Sex and age composition of marten trapped in the southern foothills of Gates of the Arctic National Park and Preserve, Brooks Range, Alaska, 1988-1993. Sex composition is given as the percentage of males (M):females (F) for a sample size of n. Age composition data consists of percent juveniles (J) and the percentage of juveniles:adult females (AF). (Juveniles are animals <2 years old as determined by tooth cementum aging.)

Trapping Season	M:F	(n)	% J	(n)	J:AF	(n)
1988-89	1.7:1[a] (63:37)	311	71	311	7.3:1 (88:12)	251
1989-90	1.6:1[a] (62:38)	60	45	60	2.5:1 (71:29)	38
1990-91	2:1[a] (67:33)	109	49	109	3:1 (75:25)	71
1991-92	1.3:1[a] (56:44)	390	43	390	1.7:1 (63:37)	265
1992-93	2.3:1[a] (70:30)	130	28	130	1.4:1 (58:42)	64
Total	1.6:1[a] (62:38)	1000	49	1000	2.7:1 (73:27)	689

[a] $P < 0.05$; Binomial Probability Test to determine divergence from a 50:50 distribution.

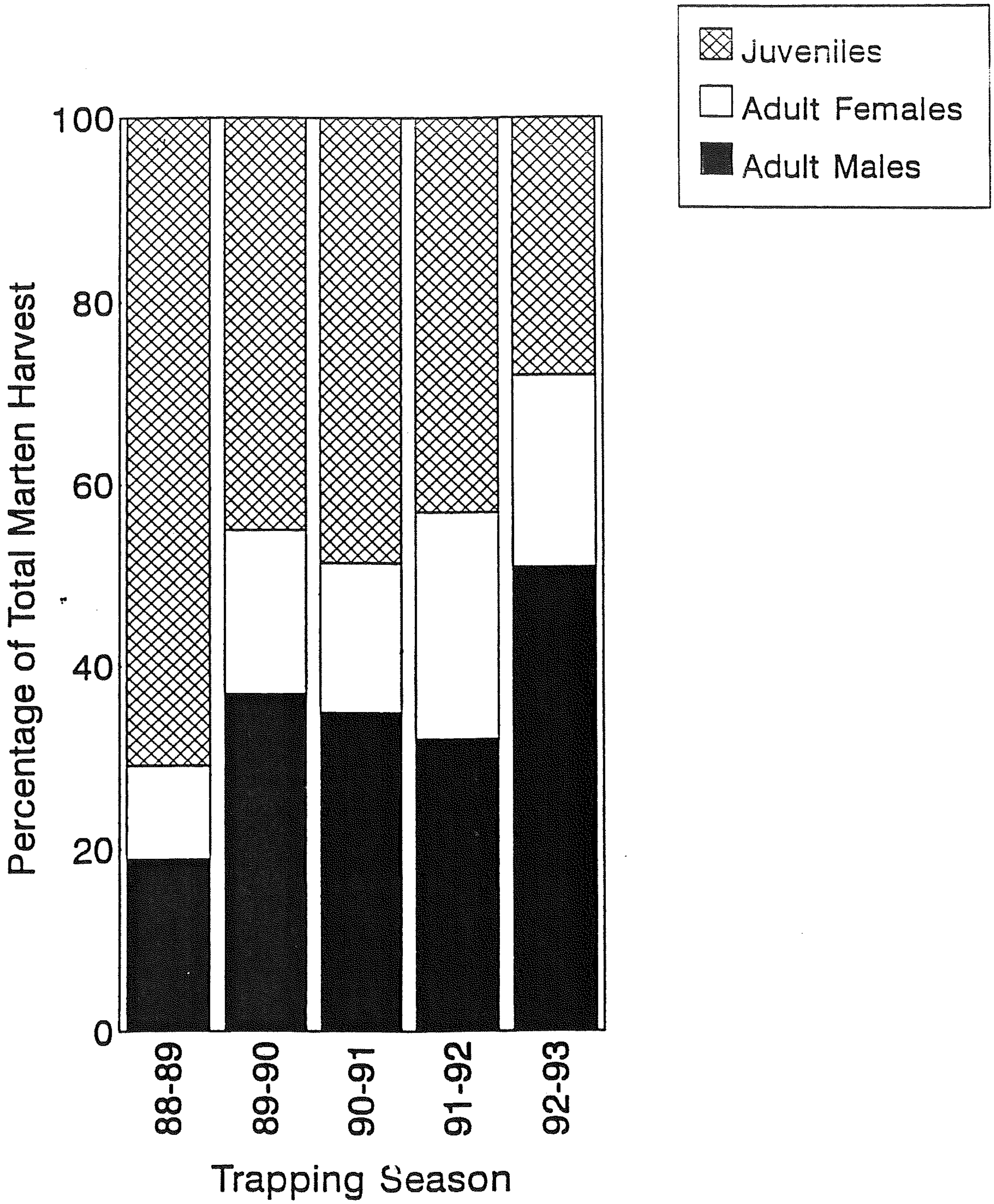

Fig. 8. Percentage of marten harvest comprised of adult males, adult females, and juveniles trapped within and near the southern boundaries of Gates of the Arctic National Park and Preserve, Brooks Range, Alaska, 1988-1993.

potential. A high percentage of pregnant juvenile females in the harvest may mean that a population is being heavily harvested and held at a low population density (Gilbert 1987). A small proportion of pregnant adult females may indicate a lightly harvested, high density population. Low pregnancy rates may also be caused by heavy harvest of adult males (Gilbert 1987).

Litter size has been used to assess population reproductive potential, though interpretation of reproductive features used to determine litter size may result in inaccurate estimates. The difficulty of correlating differing shades of placental scars to the number of live young being produced per litter has raised questions about the use of placental scars to assess litter sizes and pregnancy rates (Lindstrom 1981). Resorption sites, persistent scars from previous litters, and aborted fetuses all may result in visible placental scars that do not accurately reflect the number of live young produced in a single reproductive effort. Counts of all visible scars may overestimate litter size at birth, and scar fading over time or while uteri are being stored for future analysis may underestimate litter size at birth (Lindstrom 1981).

In general, decreased productivity, as determined by low mean litter sizes, has been associated with increasing population density and increased competition for food resources. High productivity or litter size may indicate a low density population with no competition for food resources (Wolfe and Chapman 1987).

Red Fox

Sex and age ratios for harvested northern red fox populations have not been well documented in the literature, but male-biased sex ratios in the harvest are most commonly reported from other areas. Male-biased sex ratios have been reported from heavily harvested, but stable populations in Ontario (male: female ratio of 1.3:1; Voigt 1987), Wisconsin (males composed 56-58% of the harvest; Pils et al 1981), and Germany (male:female ratio of 1.5:1; Stubbe 1980). Having more males than females in the harvest may reflect higher male activity levels and larger home ranges, characteristics which predispose them to being shot or trapped (Stubbe 1980, Pils et al 1981). Sex ratios of 50:50 have only been reported for red fox at birth (Pils and Marten 1978, Zabel 1987), but with unbiased natural mortality and/or capture probability for males and females, a 1:1 sex ratio also could appear in the harvest.

High juvenile harvests, such as those obtained in this study, may indicate high reproductive output and pup survival. Inexperienced juveniles are more prone to capture than adults and tend to be highly represented in the harvest. Juvenile compositions in harvests from the northern (82%) and eastern (73%) areas of the park were comparable to those found in Wisconsin (74% juveniles; Pils et al 1981) and Ontario (84% juveniles; Voigt 1987), both areas with high carrying capacity for red fox.

Reproductive output is determined by the age of first breeding, percentage of vixens breeding, and litter size (Voigt 1987). Food availability and vixen nutrition levels also affect reproductive output in red foxes (Lindstrom 1983). In areas of high fox density (or low food resources), few yearlings produce pups and productivity is low among adult vixens (Harris 1979). Conversely, in areas of low fox density, high annual mortality, or high food resource availability, a high percentage of vixens are reproductively active (Layne and McKeon 1956). In Ontario, with high trapping pressure resulting in high mortality and low fox density, 80-90% of the yearling vixens and 95% of the older vixens produced pups (Voigt and MacDonald 1984). The low percentage of reproductively active yearlings in both the northern and eastern portions of the park (45% and 33%, respectively) would seem to indicate moderate population densities and mortality levels; food resources also may be moderating reproductive output.

Red fox litter sizes derived from counts of placental scars range from 4.2 in parts of Europe to 8.0 in Ontario, Canada (Voigt 1987). Extrapolation of placental scars to actual litter sizes may be biased by persistence of scars from earlier pregnancies and prenatal losses (Gilbert 1987). Vixens from a highly exploited red fox population in Germany had a mean of 6.3 placental scars or fetuses, but a projected loss of 1.54 fetuses between embryonic development and 4 weeks of age was estimated (Stubbe 1980). No data is available for intrauterine losses in red fox for Alaska. In northern Alaska an average of 5 fox pups per litter was observed (Eberhardt 1977), and Jennings (1968) stated that Alaskan red fox litter sizes of 4 pups were common and as many as 10 pups per litter was not rare. Placental scar counts for vixens in both the northern and eastern areas of the park appear to be average (assuming little or no intrauterine loss) and lend further evidence to moderate fox density.

Lynx

Few female-biased sex ratios for harvested lynx (such as that found by pooling the data from this study) have been reported in the literature. A 48:52 (male:female) sex ratio was obtained from the harvest of an increasing lynx population in Alberta (Brand and Keith 1979), and a sex ratio of 45:52 was reported from a declining population on Cape Breton Island, Nova Scotia (Parker et al 1983). Sex ratios of 50:50 have been reported for 2 heavily harvested lynx populations in Quebec (Banville 1986, Noiseux 1986). Generally, male lynx comprise more of the harvest since they are more prone to capture. Male-skewed sex ratios have been reported for

Alaska (Berrie 1970, 1971, Bailey et al 1986, Route and Doyle 1991), Northwest Territories (Poole 1989a), and Ontario (Quinn and Thompson 1987).

Several possible explanations exist for the higher number of females harvested during this study. Lynx in the study area appear to be transient (J. Reakoff, trapper, pers. commun.) and those moving through the area may be predominantly females, with males traveling through a different area. Transient male lynx also could be encountering heavy trapping pressure elsewhere, leaving only resident males, resident females, and transient females to be trapped in the area. A third, though unlikely, hypothesis is that the natural sex ratio of the population may be skewed towards females through a female-biased birth sex ratio. Litter sex-ratios also have been shifted in favor of females through sex-biased litter reduction. During periods of low food resources, McClure (1981) observed neglect of male offspring in eastern woodrats (Neotoma floridana) and theorized that the loss of male offspring reduced the female's fitness less than the loss of female offspring.

Reported lynx litter sizes based on placental scars range from 2.2 in Alaska (Berrie 1970) to 4.6 in Alberta (Brand and Keith 1979); the average litter size (4.4) from this study falls at the high end of this range. High litter sizes and percentages of reproductively active females have been associated with both increasing and stable populations that are not limited by food resources and are experiencing moderate to high trapping pressure (Banville 1986, Quinn and Parker 1987). High mean placental scar counts (3.7 placental scars per adult) also have been associated with periods of snowshoe hare abundance in Alaskan lynx (O'Connor 1984).

The number of juvenile (56%) and adult females (70%) with placental scars (indicating reproductive activity) in this study is relatively high. Placental scars were observed in 53% of the harvested yearlings in central Alaska (Nava 1970). Nearly all yearlings were reproductively active in a study in Ontario (Quinn and Thompson 1987). A 3-year average of 60% reproductively-active adult females was reported from a dense lynx population in Quebec (Banville 1986).

Reproductive activity in yearling females has been linked with food abundance. Brand et al (1976) found that in regions with increasing hare populations 76% of the yearling females had corpora lutea, while only 49% had corpora lutea in areas with declining hare populations. In eastern Alaska, 72.3% of the yearling lynx had placental scars in abundant hare years, while only 28.6% had placental scars during scarce hare years (O'Connor 1984).

The proportion of juveniles in the harvest has been used as an index to population productivity and juvenile survival. Quinn and Parker (1987) speculated that a high percentage of yearlings and kittens in the harvest indicates high reproductive success. The percentage of kittens in reported lynx harvests range from 6.8% (Berrie 1970) to 29% (Poole 1989a). The proportion of kittens in the harvest in this study (12%) falls in the low to moderate range. Route and Doyle (1991) found 23.7% kittens in the harvest in southeastern Alaska and believed it comparable to a kitten harvest of >30%, which may be indicative of an expanding population. The proportion of yearlings (20%) and kittens (12%) in the pooled harvest data for this study was comparable to those found in Quebec (10.9% yearlings and 15.8% kittens) during the first 2 years of commercial trapping in an area where lynx had not been previously trapped (Noiseux 1986). Quinn and Thompson (1987) also reported similar juvenile harvest statistics (kittens composed 20% and yearlings 13% of the harvest) for a moderately trapped lynx population in Ontario. Kittens may compose a smaller proportion of the harvest than yearlings because they are less vulnerable to trapping while with the female (Quinn and Parker 1987).

The average litter size and percentage of adult and juvenile female lynx with placental scars in this study indicate that productivity should be relatively high. However, the low proportion of juveniles in the harvest, particularly in 1992-93, suggests that juvenile survival may be low. Survival of juvenile lynx is closely tied to prey (snowshoe hare) abundance. When food supplies are limited, kitten growth and development is inhibited and, consequently, survival and recruitment rates for that cohort are low (Brand and Keith 1979). O'Connor (1984) found 22% kittens in the harvest during first winters following winters of snowshoe hare scarcity in Alaska, but 76% during first winters following winters of hare abundance. Observations from trappers in the area indicate that though snowshoe hare densities are not as high as they have been in the past, there are pockets of hares throughout the area that reach fairly high densities. It is possible that older resident lynx are able to defend high prey density patches in the study area from juvenile animals and force them into adjacent areas with low prey abundance, thereby lowering their chances of survival.

Wolverine

Male-dominated sex ratios are frequently obtained for wolverine harvests as reflected in the fur sealing records for game management units in Alaska (Abbott 1993). An overall male:female ratio of 1.64:1 was obtained for wolverine in Alaska, though a ratio of 1:1 was obtained for wolverines 5-years old and older in the sample (Rausch and Pearson 1972). Male-dominated sex ratios for wolverines may be the result of larger home range sizes for resident males or dispersal activities of young transient males (Rausch and Pearson 1972, Hornocker and Hash 1982, Magoun 1985).

Adult female wolverines often shift their home ranges to accommodate their female offspring, while male offspring are forced to disperse and establish their own territories, making them more vulnerable to capture (Magoun 1985). Magoun (1985) cautions that sex ratios from harvested animals often do not reflect the actual sex ratio of the population and may be a function of harvest pressure, timing, method, or location. For example, if heavy trapping pressure occurred in mid- to late spring, males are more likely to be trapped or shot than less active females that are spending time in dens with young.

The juvenile component of the wolverine harvest (74.5%) in this study was higher than the 55% juvenile harvest calculated from Rausch and Pearson (1972). Both studies had similar proportions of kits in the harvest (38% in the park area and 36% in Rausch and Pearson's data), but 17% more yearlings were harvested in the park area. The relatively high percentage of harvested juveniles in this study may indicate either a healthy population with high reproductive output and juvenile survival or, as suggested by Magoun (1985), a heavily exploited local population where resident animals have been removed and individuals establishing territories are juvenile immigrants unfamiliar with the area and therefore easily captured.

Low reproductive output is characteristic of wolverines due to low pregnancy rates, small litter sizes, erratic litter production, and low kitten survival (Hash 1987). Post-partum litter sizes for wolverines range from 1 to 5 kits, with 2 to 3 being average (Hash 1987). The mean in utero litter size of wolverine (based on placental scars) in Yukon was 3.3 +/- 1.2 S.D. (Banci and Harestad 1988). A mean of 2.2 embryos or fetuses/litter was obtained from 6 female wolverines in Montana (Hornocker and Hash 1981), and a mean of 3.4 placental scars was obtained from female wolverines collected in Alaska and Yukon (Rausch and Pearson 1972). The mean litter size obtained in this study from placental scar and fetal counts (3.0) was moderate. Rausch and Pearson (1972) calculated that the number of kittens surviving the first summer averaged 1.5 young per female less than indicated by the in utero data.

The 4 of 9 adult females with placental scars or fetuses in this study results in a relatively low percentage of reproductively active adult females (44%); examination of the ovaries for corpora lutea may have increased the number of reproductively active adults detected. Eighty-eight percent of 26 adult female wolverines (2 years old and older) examined in British Columbia (Liskop et al 1981) and 90% of 98 adult females (2 years old and older) in Alaska and Yukon (Rausch and Pearson 1972) were pregnant or post-partum. Yearling wolverines in this study were nonreproductive, as were those in British Columbia (Liskop et al 1981). However, 7.4% yearling wolverines in Yukon had corpora lutea present, indicating pregnancy (Banci and Harestad 1988).

Marten

Male marten are harvested more often than females because of their wider ranging/foraging habits, which increase their likelihood of encountering a trap (Yeager 1950, Lensink 1953, Soukkala 1983). Trappers in the study area also maintain that the sex composition of the harvest is a function of the trap set used--i.e., male marten appear to be caught most often in pole sets, while females are more likely to get caught in cubby sets. Strickland and Douglas (1987) found that males were caught 2-3 times more often than females in Ontario. In addition to the findings of this study, male-skewed sex ratios were reported for marten harvests in 2 villages in Northwest Territories (1.56:1 and 1.27:1; Poole 1989b) and the Nowitna National Wildlife Refuge in Alaska (1.4:1; Paragi and Johnson 1993). I found no female-biased sex ratios reported for marten harvests, but female-skewed and 1:1 ratios have been obtained from individual trapper catches (A. Magoun, AK Dep. Fish and Game, pers. commun.) and in small, localized areas (Swanson 1992b). Sex ratios nearly equal or dominant to females have been associated with overharvest (Strickland and Douglas 1987).

The increased capture of adults and particularly adult female marten in this study (Fig. 8) may indicate low food resources. Marten density, movements, and reproductive rates are closely tied to food abundance and small mammal densities (Lensink et al 1955, Weckwerth and Hawley 1962, Thompson and Colgan 1987). Increased foraging time due to food shortage increases marten vulnerability to trapping (Yeager 1950, Thompson 1986). In addition to the increased loss of female marten to trapping during periods of food scarcity, reproductive productivity declines through decreased number, size, and survival of litters (Weckwerth and Hawley 1962). Thompson and Colgan (1987) report that dispersal of resident marten from food-depleted home ranges has resulted in higher percentages of adults in the harvest.

The decreasing juvenile harvest in this study may warrant further monitoring. A ratio of more than 3 juveniles per adult female is considered an acceptable harvest ratio in Ontario (Strickland and Douglas 1987), and Thompson and Colgan (1987) felt that harvest quotas should be reduced when 3 or less juveniles were harvested per adult female. Juvenile:adult female harvest ratios dropped from 7.3:1 in 1988-89 to 1.4:1 in 1992-93 (Table 7). Decreased trapper effort may have affected the number of juveniles harvested in 1992-93. Heavy snows and extreme cold temperatures during 1992-93 prevented trappers from checking traplines and keeping them open, and several trappers pulled their traps in December. Low numbers of juvenile marten in the 1992-93 harvest were also found on the Nowitna National Wildlife Refuge southwest of the park and preserve (Paragi and Johnson 1993); yearling females trapped on the Nowitna in 1991-92 had low corpora lutea counts and pregnancy rates which may have contributed to the lack of juveniles in the 1992-93 harvest.

A low juvenile harvest component also could be associated with the increased juvenile mortality and dispersal occurring during periods of food shortage (Weckwerth and Hawley 1962, Thompson and Colgan 1987). In Ontario, juveniles initially made up 38-63% of the harvest, but as food abundance declined, these percentages dropped to 16% and 3% in the following 2 years (Thompson and Colgan 1987). In this study, the percentage of juveniles in the harvest dropped by 43% during the 5-year period, and low food resources may have contributed to this decline.

MANAGEMENT IMPLICATIONS

Red fox population levels appear to be moderate and stable in the northern and eastern park and preserve areas. Given the sex, age, and reproductive data from the harvested red fox populations and the fact that trappers have been expending little effort on red fox in recent years (probably due to steadily dropping pelt prices since 1987; Osborne 1993), no further monitoring appears to be necessary at this time. Annual fur prices, however, should be followed to note any increases in red fox pelt prices that may increase trapping pressure and harvest levels. Trapper's observations on red fox density also should be solicited to gain additional knowledge of population trends.

Though lynx harvest data do not indicate any immediate cause for harvest regulation change, the female-dominated sex ratio and apparent low juvenile survival rate may lead to low lynx density in the area (particularly if trapping pressure in the area increases) and should be monitored. A monitoring strategy that incorporates the sex and age structure and reproductive output of harvested lynx with hare density estimates for the area in question is recommended. With information on hare density, the percentage of kittens and yearlings in the harvest, and litter sizes based on placental scar and/or corpora lutea counts, managers can more reliably predict lynx population trends and identify potential factors driving them. Additionally, habitat areas that consistently support hare populations (particularly in times of low hare abundance) should be identified and mapped to facilitate designation of protected refugia should the need arise.

If harvest data accurately reflect actual population trends, wolverine populations appear to be sufficiently healthy and able to sustain current harvest levels. Continued monitoring of the age structure of the harvest and female reproductive indices (corpora lutea and placental scar counts) is recommended to determine if the percentage of juveniles in the harvest is the result of (1) high reproductive success and survival of kits in the population or (2) heavy exploitation, where juvenile immigrants are being harvested after resident animals have been removed. More detailed information on where and when wolverines are being trapped will be necessary to ascertain if (2) above is occurring since this situation only occurs in specific areas where trapping pressure for wolverine has been heavy for a number of years (A. Magoun, AK Dep. Fish and Game, pers. commun.). Denning habitats and high density wolverine reservoir areas should be identified for future conservation efforts stemming from apparent population decline and/or substantially increased trapping pressure.

The declining juvenile cohort in the marten harvest during this study warrants further monitoring. More detailed information on the number of trappers, trapper effort, and trapping history for the area is needed to better understand the relationship between marten harvest and the marten population level. Sex, age, and reproductive data from harvested marten in specific areas should be collected simultaneously with prey abundance data from those same areas. Information on food abundance would help managers to determine if marten population declines are related to food scarcity. High density marten areas associated habitat types also should be identified (through winter track densities and/or trapper knowledge); this information will be required if future harvest levels require establishment of protected reservoir areas to augment harvested populations.

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APPENDIX I. Number of trappers from which red fox, lynx, wolverine, and marten carcasses were purchased during 5 trapping seasons from 1988-89 to 1992-93, Gates of the Arctic National Park and Preserve, Brooks Range, AK.

	Trapping Season				
Species	1988-89	1989-90	1990-91	1991-92	1992-93
Red Fox					
North	9	3	2	5	
East	2	1	2	3	5
Lynx	1	1	2	3	5
Wolverine	4	5	4	6	2
Marten	13	6	6	10	7